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Problematic plate reconstruction

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To the Editor – As has been previously proposed[1,2], Bronner *et al*.[3] suggest that opening of the rift between Newfoundland and Iberia involved exhumation of mantle rocks until 112 million years ago, subsequent seafloor spreading, and crustal thickening along the high-amplitude J magnetic anomaly by magma that propagated from the Southeast Newfoundland Ridge area. Conventionally, the anomalous magnetism and basement ridges associated with the J anomaly north of the Newfoundland-Gibraltar Fracture Zone are thought to have formed about 125 million years ago at chron M0[2,3] (Fig. 1a), although the crust probably experienced some later magmatic overprinting[4]. The M0 age would make their formation simultaneous with that of the similar J anomaly and basement ridges (the J Anomaly Ridge and Madeira Tore Rise) along the Mid-Atlantic Ridge to the south[5,6] and place them within a zone of exhumed mantle in the Newfoundland-Iberia rift[2,3]. In contrast, Bronner *et al*.[3] propose that the J anomaly and associated basement ridges were formed by later magmatism (about 112 million years ago) that marked the end of mantle exhumation in the rift. We argue here that constraints from plate tectonic reconstructions render this possibility untenable.

The magnetic model central to the Bronner *et al*.[3] paper is plausible (although no more so than models based on M-series geomagnetic reversal data[2,7-9]), but it is problematic in terms of plate reconstructions. Bronner and colleagues propose that an offset between the axes of the Mid-Atlantic Ridge and Newfoundland-Iberia rift at the Newfoundland-Gibraltar Fracture Zone around 125 million years ago (M0 offset ~70 km; bold dashed lines, Fig. 1b) inhibited northward transport of magma from the Southeast Newfoundland Ridge for about 10 million years. If true, such a scenario would

necessitate rapid propagation of magma through the rift by 112 million years ago, and thus require the J anomaly there to have formed almost isochronally. During the period between 125 and 112 million years ago the conjugate J Anomaly Ridge and Madeira Tore Rise south of the Newfoundland-Gibraltar Fracture Zone became widely separated (Fig. 1b). However, by about 84 million years ago (chron C34, Fig. 1d), the Madeira Tore Rise north of the Newfoundland-Gibraltar Fracture Zone was collinear with the Madeira Tore Rise to the south and has remained so to the present[7]. Thus, the scenario proposed by Bronner and colleagues would require that: 1) a left-lateral offset of the Newfoundland-Gibraltar Fracture Zone of more than 100 km that existed about 112 million years ago (Fig. 1b), reversed to become a 100 km right-lateral off set by 84 million years ago (Fig. 1d); 2) the plate separation rate just north of Newfoundland-Gibraltar Fracture Zone was at least ~1.5 times faster than to the south for some period after 112 million years ago but it dramatically slowed to the African-North American rate by 84 million years ago; and 3) within the same time frame, separation between the Iberian and North American plates serendipitously aligned the formerly offset segments of the Madeira Tore Rise located north and south of the Newfoundland-Gibraltar Fracture Zone.

The presumed reversal of offset of the Newfoundland-Gibraltar Fracture Zone and discrepancy in extension rates occur within the Cretaceous Magnetic Quiet Zone and thus are unconstrained by geomagnetic age data. However, they seem highly unlikely. More importantly, the required alignment of the northern and southern Madeira Tore Rise is too coincidental to be believed.

Alternately, if northward propagation of magma from the Southeast Newfoundland Ridge was prolonged for 10 million years, rather than delayed, a significantly diachronous J anomaly would result (Fig. 1c). This too is problematic. There is no excess magmatism observed in the wake of a supposed propagator, nor was there any mirrored, southward propagation south of Newfoundland-Gibraltar Fracture Zone. Thus, any melt anomaly that drove propagation from the Southeast Newfoundland Ridge ceased to exist well before 112 million years ago. Therefore, prolonged propagation

would require the unreasonable assumption that an isolated melt anomaly was moving northerly through the mantle of the Newfoundland-Iberia rift, creating a track in the seafloor nearly opposite in direction to that expected from absolute plate motion[10]. We conclude from the plate-kinematic constraints that formation of the J-anomaly complex in the Newfoundland-Iberia rift about 112 million years ago is not a viable proposition and thus that its predicted consequences are not pertinent to the rift evolution.

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Figure 1 | North Atlantic plate reconstructions. **a,** Conventional chron M0 reconstruction of the African-North American[7] and Iberian-North American[8] plates, which assumes that the J anomaly both north and south of the Newfoundland-Gibraltar Fracture Zone (NGFZ) formed about 125 million years ago. J Anomaly Ridge (JAR) and

Madeira Tore Rise (MTR) basement ridges shaded and seafloor isochrons identified. **b,** Plate reconstruction at 112 million years ago assuming nearly isochronal formation of the J anomaly by this time in the Newfoundland-Iberia rift. African and North American plate positions interpolated between chron M0 and C34 reconstructions[7]. Bold dashed lines indicate earlier, M0 extension axes on the North American plate (chron M0 south of the NGFZ; assumed extension half rate ~7 mm/yr north of NGFZ[2]). Ocean Drilling Program drill sites 1277 and 1070 indicated. **c,** Plate reconstruction at 112 million years ago, assuming JAR-MTR ridges formed by prolonged propagation (arrow) of an isolated magma anomaly northward from Southeast Newfoundland Ridge (SENR) between about 125 and 112 million years ago. **d,** Chron 34 plate reconstruction[7]. MAR, Mid-Atlantic Ridge; FC, Flemish Cap; GB, Galicia Bank.

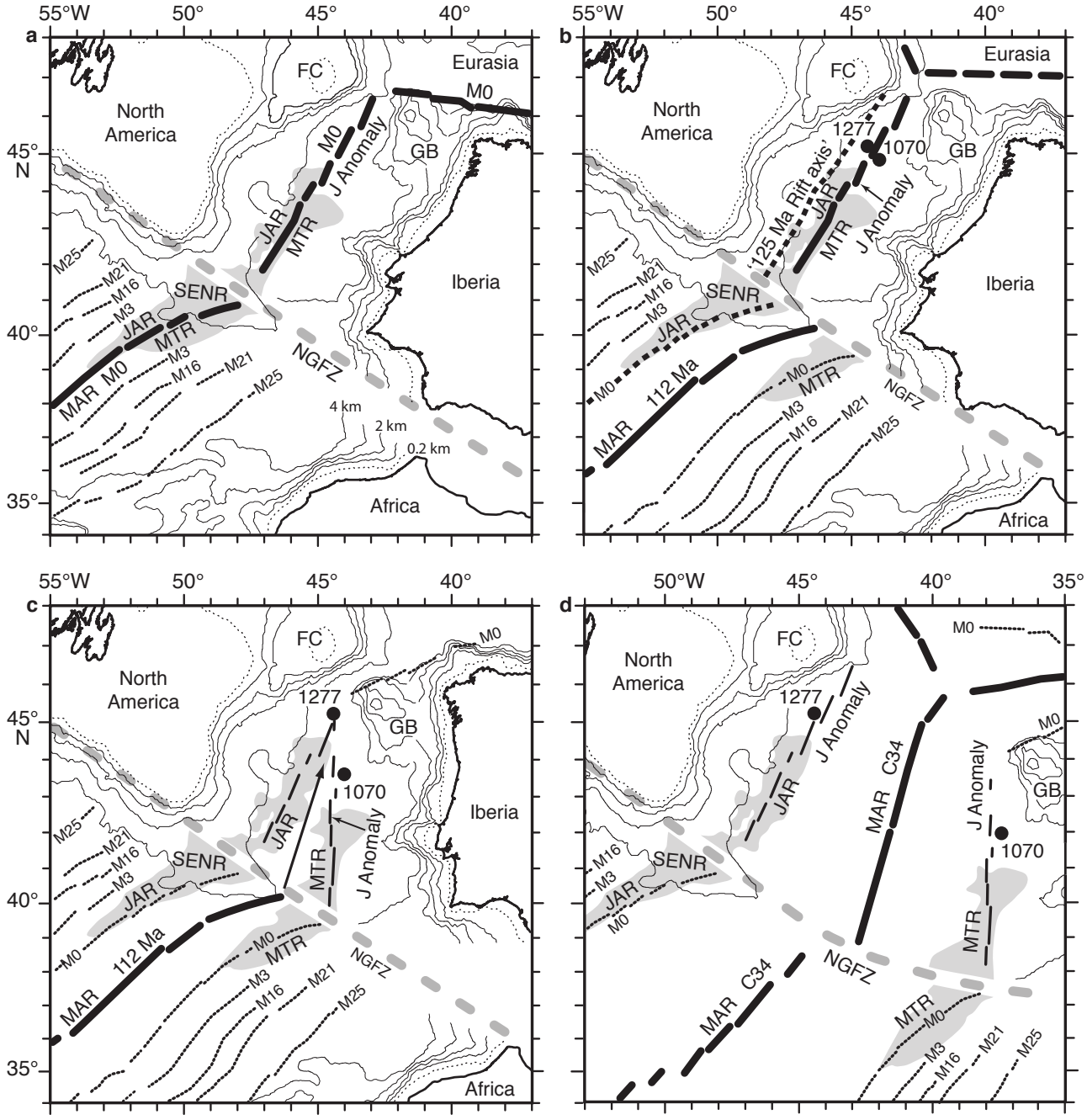

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Figure 1. Plate reconstructions.